

Review of Research on Potato Varieties for French Fries and Chips Processing Industry

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ABSTRACT:

Field trials were conducted at TADCO during the period 2006 – 2012 on potato varieties mainly for processing chips and French fries. Field Tests and Lab analysis tests in the spring and autumn 2006 trials showed three varieties of promising results: Markies variety was a medium day variety with average productivity 50.58 M.T./Ha, %dry matter 21.07, %reduced sugar 0.04, round, oval shape; Fontane variety was a medium day crop with average productivity 43.47 M.T./Ha, %dry matter 20.92, %reduced sugar 0.03 oval shape; Mustang variety was a red skin variety with productivity 41.18 M.T./Ha, %dry matter 20.80, %reduced sugar 0.02, round shape. Results in spring 2008 showed an early potato, Donald variety with high %dry matter 21.60, and low %reduced sugar 0.01 with good frying color which was accepted by all chips factories. Results in the autumn of 2009 confirmed Fontaine top quality and productivity over other varieties with 46.47 M.T. /Ha, %dry matter 20.8, %reduced sugar 0.02. Results in autumn 2011 and spring 2012 showed two French processing varieties Oceania and Fridor. Both were with top processing qualities, but productivity was low for Fridor and medium for Oceania. Oceania was with yellow skin and flesh, short oval to an oval shape, productivity in spring season reached 36.51, %dry matter 22.20, and % reduced sugar 0.01 with good frying color grade # 1 to 2. Arnova table potato variety was observed with high productivity 63.89 M.T. /Ha in the 2006 spring season; it was an early-medium day variety, big tubers size, oval long, light yellow flesh. Over the years, successful potato varieties were adopted by the company for crop production like Markies, Mustang, Donald, and Hermes; or abandoned due to technical reasons like Agria and Lady Olympia.

Keywords: Potato Variety, Productivity, %Dry Matter, %Reduced Sugar, French fries.

I. INTRODUCTION

Potato is an important vegetable crop in Saudi Arabia; the estimated annual production ranged from 450.000 to 500.000 MT. The potato crop is grown in the northwest of Saudi Arabia in two main seasons: spring season, planted in early February, harvested in June, and autumn season planted in

late July until mid-August and harvested at the beginning of December and continued until the first week of February [1]. Sometimes, potato is planted in early July to be harvested in November, and therefore the crop may be present in the fields throughout the year. The potato crop in this area needs a period of 100-130 days to complete the production cycle. Planting potato crops outside the previous dates is encountered with low yield and low quality due to unfavorable climate conditions [2]. The climate in this area is characterized by moderate temperatures in most months of the year with warm days and cold nights, except few months in the summer and winter seasons. The average temperature in the period from June to the end of August range between 37 - 40°C, and its rise to a range of 42 - 44°C for a few days in the months of July and August. In the winter months, the average minimum temperature range between 3 - 4°C degrees in the period of December to February, and the temperature drops below zero for a few days in the months of this period.

TADCO is located near Tabuk city, and it was one of the leading Saudi companies on crop production of field crops, vegetable crops in addition to the production of fruit crops, grapes, and olives. They succeeded in achieving high yields and high quality of various crops, including potato and onion, due to high water quality, suitable sandy loam soil, professional irrigation management, and skilled manpower. The company was considered as the single biggest potato producer in Saudi Arabia, supplying over 65% of the requirements of the Saudi French fries factories from locally grown potatoes [1]. The company focused on producing potatoes with the required specifications for French fries and chips factories, and this was very good for the factories themselves because this lowers their unit production costs.

As per TADCO, the strategic plan was to test new potato varieties for processing chips and French fries to satisfy the requirements of the local factories in Saudi Arabia. For this purpose, new potato varieties were either imported or sent from prominent potato seed companies in Europe and North America. The main object of this research work was to review the research results on selected potato varieties for processing French fries and chips.



II. MATERIALS & METHODS

A- Land Preparation: Typical land preparation for planting potato crop after wheat crop involved: straw burning followed pre-irrigation of two rounds of irrigation at a speed of 20% with a total amount of 37.6 mm. The irrigation process was followed by soil cultivation with a chisel plow at a depth of 15-18 cm, then broadcast NPK fertilizer 14-38-10 at the rate of 280 kg/Ha followed by cross chisel plow at a depth of 30 cm in the opposite direction (45° angle). The pivot was left until planting; another round of 20% irrigation was applied, followed by disking using a power harrow to break the soil clods and level the soil just before planting.

B- Trials Layout & Planting: Research unit, in coordination with top management and vegetable production managers, conducted small-scale trials and followed large-scale trials in the commercial potato pivots at TADCO during the period 2006 – 2012. Small scale trials when the potato seeds were of limited quantity 50 to 100 kg and large scale trials when there were enough potato seeds for mechanized operations.

For large-scale varietal trials: select the location of the trial in a leveled area in the selected pivot 150-180 meters from the service road on the left or right side of the pivot. Use the planter to plant four straight lines or more of each variety across the pivot dependent on the available potato seeds using a four-row Grimme planter at a row distance of 90 cm, and distance between the seeds in each row 25 – 30 cm with a seed rate of around 3 M.T./Ha. Plant the second and next varieties in the same manner. Make a map indicating the row numbers for the start and end of each variety, and mark it with a post with the name of each variety. Each tower area was considered as one replicate (plot) unit.

For small scale varietal trials, select the location of the trial 10 meters away from the service road or near the edge of the pivot, manually plant the seeds in one strip (bed) of four rows of 90 cm spacing at a distance of 25 to 30 cm between the seeds. Make a map indicating the row numbers for the start and end of the trial strips, and show the location of each variety in the trial.

For the potato trials conducted at the research pivot, the following map illustrates the arrangement of the potato varietal trial conducted in February 2012 at A04P25; see **Figure 1**. Four-row planters were used with 90 cm row spacing. Planting of each variety was arranged into separate strips, and each strip was four rows extending from the start of tower 4 to the end of tower 6 with a total length of 165 meters and a width of 3.6 meter. Each strip (bed) consisted of 3 plots separated by the center pivot tires; each plot is 55 meters in length with a 3.6-meter width. The area of each plot = $55 \times 3.6 = 198 \text{ M}^2$

Area of each strip (bed) = $198 \times 3 = 594 \text{ M}^2$

Area of each variety of two strips = 1188 M^2 .

The source of potato seeds was from the commercial seeds companies as follows:

Holland [3], [4], like Agrico for Markies, Agria, Arnova,

Sonora, Fontane etc.; Meijer for Lady Olympia and Stet for Donald.

France like Treskalia for Oceania, Fridor.

Germany likes Euro plant for Nora, Camilla, Clarina, Topas, Agnes.

Saudi Arabia like ASTRA for Mustang, Almera, Fontane, Hermes. Ditta etc., from Holland.

Al Mahlia for Shepody, Carola from the USA.

C. Crop Maintenance: Daily activities for potato crop maintenance were carried out by the Vegetable Section personnel in the production pivots or Research Unit personnel in the research pivot, and it involved irrigation, fertilizers application, pest and disease control, and supervision of crop harvest, transportation, and storage.

After planting, start irrigation the first two rounds at 50%, then 100% speed with 1000 GPM in summer or 800 GPM in spring.

Control of summer weeds and perennial alfalfa new growth using Glyphosate 6 liter + Agral 0.1 liter/ ha two weeks after planting dependent on the alfalfa growth. At the start of potato crop emergence, control germinating broadleaf weeds and grasses using Sencor herbicide 0.6 kg/ ha, and spray Super Gallant herbicides 1.5 liter/ha to control grasses when the plants reach 20 – 30 cm height.

Control of potato pests and diseases such as caterpillars, potato tuber moth, leaf minor, aphids, early blight based on their historical prevalence and incidence using recommended chemicals such as IGH insecticides like Cascade or Nomolt for leaf minor, caterpillars, and PTM; use Remiltin or Ridomil or Kocide to control blights and Dimethoate for aphids control.

Start fertilizers injections after emergence (plant height 20-30cm) using urea into weekly doses of 5-20 kg/ha dependent on the stage of plant growth, and mix it with 5 liters liquid fertilizer 5-75-3 for three weekly doses. Inject Rexene trace elements fertilizer 1 kg/ha for two doses mixed with the urea injections after 50 and 60 days from planting. Topdressing the whole planted pivot with granular NPK fertilizer 11-29-19 at a rate of 100 kg/ha plus granular potassium sulfate fertilizer 200 kg/ha before ridging. Start ridging the plants 50 – 70 days after planting when the plants reach complete emergence with 20-30 cm height, followed by blocking the rows to increase irrigation efficiency. At tuber initiation (flowering appears) onwards, start urea program injections at the rate of 20 – 30 Kg/ha every 5 days for around two months, and stop the urea fertilizer program one month before harvest. The average fertilizer quantities applied per hectare per season is around: Nitrogen 200 kg, P₂O₅ 120, K₂O 200 kg. It was estimated that the amount of irrigation water consumed through the spring growing season per hectare was about 850 mm, and for the autumn season, 1100 mm, including pre-irrigation of about 80 - 105 mm before planting, one mm equals 10 M³/ha.

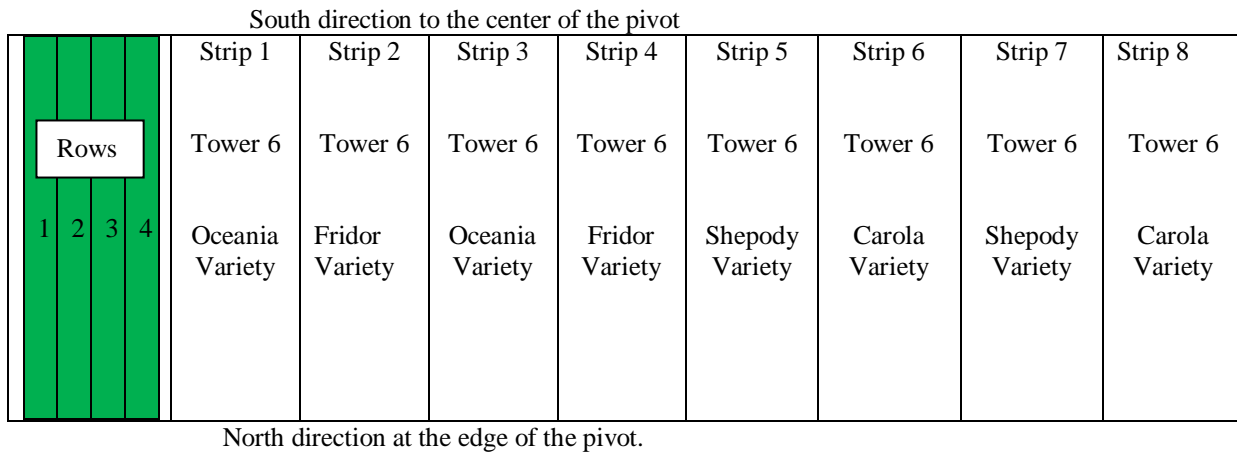


Figure 1. Distribution of potato varieties in the trial at the research pivot A04P25 in the 2012 spring season.

D. Data Recording: To compare the different potato varieties with each other in each trial: research personnel were directed to monitor the crop development at each pivot trial during the growing season, and record the number of plants/linear meter, number of stems per plant, and notes on the maturity date. Test harvest was conducted before the final harvest on four locations of each variety, each sample was one linear meter, the collected tubers samples were labeled and sent to the Lab to study the quality characters of the potato varieties such as % dry matter, and % reduced sugar, the percentage of each potato size and the weight (kg) /linear meter. Statistical analysis for the productivity of the potato varieties was carried out using Statistics10 to measure the significant difference between the potato varieties. Marketable and profitable new varieties were characterized by high productivity, high quality of processed potato, and accepted by the end-user.

E. Testing Potato Tubers Qualities [5], [6], [7]: Representative potato tubers samples, each around 10 kg, were sent after harvest to the lab, labeled with the name of the variety, location, date of sampling, etc. The lab technicians record the samples in the logbook with the corresponding laboratory number. The tubers in each sample were washed with water then checked: remove small, and large tubers above 75 mm and deformed or diseased ones.

E1. %Dry Matter Test [5], [6]: Randomly choose the tubers sample, and weigh 3.63 kg and put it in the metal basket of the hydrometer. Attach the hydrometer to the basket and carefully put it into a plastic barrel partially filled with 200 liters of water. Allow the basket to stay in the water for 2-3 minutes without carrying it; while the potatoes are in the basket of the hydrometer under the water, read the %dry matter and the specific gravity located at the graduated marks

of the hydrometer. The acceptable level for French fries and crisp should be above 19%.

E2.%Reduced SugarTest [5], [6]: Randomly collect 6-10 tubers from the metal basket to measure %reduced sugar; cut each tuber longitudinally, then discard three parts and take one part. Cut the chosen parts into small pieces of 0.5 – 1 cm, put it in the container of a fruit mixer, and blend it for three minutes to produce homogenized paste using low speed then intermittent high speed. Transfer the paste into a polyethylene bag and label it, then filter the sample to collect the juice. After 5 – 10 minutes, add 1 -2 droplets of potato juice to the glucometer. The timer will beep after 45 seconds and read the displayed results.

$$\% \text{ Reducing sugar} = (\text{Glucometer reading mg/dl} \times 0.036) / 18$$

The following table shows the relationship between the reading of the glucometer Melli Mole/Liter or Mg/Dcl and %Reduced Sugar. The acceptable level for French fries should be below 0.4%, and for chips should be below 0.2%.

Melli Mole/Liter	4	5.6	7	11	15	20	25
Mg/Dcl (100 ML)	80	101	120	200	272	363	454
%Reduced Sugar	0.14	0.20	0.25	0.39	0.54	0.72	0.95

E3. Frying Test for Chips [5], [6]: Randomly collect 6-10 tubers from the previously tested sample, and cut the tuber into pieces of 1.3 mm thickness by the chips cutting machine. Wash the sliced pieces into a bowl full of water to remove the starch, then transfer the potato slices to a strainer container and leave the slices for half an hour while shaking the container from time to time to get rid of water. . Prepare the electric frying pan with fresh vegetable oil, and heat the



Figure 2. Potato chips color grades 1 – 5



Figure 3. Acceptable Potato French Fries grades # 1 and 2

Oil until the oil temperature reaches 175° C. Transfer the potato slices into the chips container in the frying pan, and leave it into the hot oil for three minutes while moving the chips container carefully into the oil tank to increase the chance of the oil touching the chips. Transfer the fried slices to a strainer container and leave it for half an hour to cool down and drain the oil. Determine the chip's color grade as per the visual Agrotan colored picture cards shown in **Figure 2**. The colored pictures are matching the USDA color standards for frozen French fried potatoes, which was developed by Munsell color company Inc., Baltimore USA [5], [8].

E4. French Fries Test [5], [8]: Randomly collect 6-10 tubers from the previously tested sample. Cut the tubers into pieces of 7 cm length with 1 cm thickness by the chips cutting machine. Transfer the pieces to a bowl with water to remove the starch, then transfer to a stainless steel container with hot water and boil the water at 85 C° for 35 seconds. Transfer the potato pieces to a strainer container and leave the slices for

half an hour while shaking the container from time to time to get rid of water. Prepare the electric frying pan with fresh vegetable oil, and heat the oil until the oil temperature reaches 180 C°. Transfer the potato pieces into the chips container in the frying pan, and leave it into the hot oil for 35 seconds while moving the chips container carefully into the oil tank to increase the chance of the oil touching the chips. Transfer the French fries to a strainer container and leave it for half an hour to cool down and drain the oil. Pack the French into a polyethylene bag and store the French fries in the freezer at – 25° C overnight. Transfer the French fries from the freezer on the next day and fry them at 180° C for 7 minutes. Transfer the French fries to a strainer container and leave it for half an hour to cool down and drain the oil, then test the color, texture, and taste as the acceptable French fries is with a golden color and little red, hard and crunchy with the desired taste as shown in the pictures of **Figure 3**. The acceptable color level was 1 and 2.

III. RESULTS & DISCUSSIONS

A. Observations on the 2006 potato trials:

a) **Spring potato 2006 trial:** Thirteen potato varieties samples [9], [10], each of 50 kg, were planted on January 31, 2006, at F18P35 along with the Diamant main potato crop. Five varieties from Euro plant Co. in Germany: Nora, Camilla, Clarina, Topas, Agnes; and eight varieties from Agrico Co in Holland: Marlien, Mustang, Almera, Agria, Sinora, Arnova, Fontaine, and Markies. Test harvest was conducted on June 15, 2006. The results of the field observations and laboratory analysis are presented in **Table 2 and Figure 4**; we observed the following:

- Six varieties were of top quality: Clarina, Topas, Agnes, Mustang, Fontaine & Markies, and two varieties were of

very good quality: Camilla, Sinora, and three varieties reached the acceptable level for % dry matter.

- Arnova & Almera were with high productivity, which reached 63.89 and 40.56 M.T./ha, respectively, but they did not reach the acceptable level for processing, so these varieties were suitable as table potato varieties.

- Euro plant varieties (Camilla, Clarina, Topas, Agnes) were of high quality, but the yield range 19.4 – 26.67 M.T./Ha, which was less than the yield of Agrico varieties like Markies, Fontane, Mustang, and Sinora. So further trials were needed to ascertain their productivity.

- The productivity of the main crop Diamant variety, reached 40.04 M.T./Ha.



Figure 4. Potato varieties tested in the spring season of 2006 at F18P35

Table 2. Field observations and laboratory analysis results on the spring potato varieties of the 2006 season at F18P35.

Variety	Test Harvest Kg/LM*	Productivity M.T./Ha	% Dry Matter	%Reducing Sugar	Specific Gravity	Tubers Characteristics, and notes on maturity.
Nora	2.25	25.00	19.8	0.01	1.079	Yellow flesh, round oval, long day variety
Camilla	2.40	26.67	20.8	0.03	1.084	Light yellow flesh, round oval, early to medium
Clarina	1.75	19.40	21.6	0.01	1.088	Light yellow flesh, round oval, medium day
Topas	2.30	25.56	21.4	0.02	1.086	Yellow flesh, Long oval, short day variety
Agnes	2.35	26.11	21.4	0.02	1.086	Yellow flesh, round oval, early to medium Var.
Marilen	1.95	21.67	19.8	0.01	1.079	Light Yellow Flesh, Long oval, short day var.
Mustang	3.75	41.67	21.0	0.01	1.085	Red skin, Yellow Flesh, round, medium day
Almera	3.65	40.56	17.6	0.11	1.068	Light Yellow Flesh, Long oval, medium day
Agria	3.10	34.44	19.0	0.01	1.075	Yellow Flesh, round oval, early to medium
Sinora	2.25	25.00	20.4	0.01	1.082	Light Yellow Flesh, round, early to medium
Arnova	5.75	64.40	17.2	0.4	1.067	Light Yellow Flesh, Long oval, early to medium
Fontaine	3.30	36.67	21.2	0.01	1.086	Light Yellow Flesh, round, early variety
Markies	4.15	46.11	21.4	0.01	1.087	Light Yellow Flesh, round oval, medium day
Acceptable Level for French fries;			> 19%	< 0.4%	1.076	
Acceptable Level for Chips			> 19%	< 0.2%	1.076	

** Mean of 4 linear meters

b) **Autumn potato 2006 trial:** Thirteen potato varieties from the spring 2006 trial harvest [9], [10] along with lady Olympia [11] were planted on August 9, 2006, at E05PB05

along with the Diamant main potato crop, each variety was planted in an area of 50 M² and arranged into four rows of 90 cm spacing. The potato plants were subjected to frost damage

on December 05, 2006 (116 days after planting. Test harvest sampling started on December 09, 2006; each variety was harvested separately and kept in a labeled polyethylene bag. The results of the field observations and laboratory analysis are presented in **Table 3** and **Figure 5**. We observed the following:

- Eight varieties out of fifteen potato varieties were above 40 M.T. /Ha. Arnova was the highest, which reached 62.39

M.T./ha followed by Markies, Fontaine, Sinora, Almera, Agria, Agnes, and Mustang with 55.06, 50.28, 49.74, 45.19, 42.85, 42.53, 40.69 M.T./Ha respectively, and these results were higher than the yield of the main crop Diamant variety with 40.06 M.T./Ha. The productivity of the Europlant potato varieties were 42.53, 31.56, 31.22, 26.91, 12.34 M.T./Ha for

Table 3. Field measurements and laboratory analysis results on the autumn potato varieties of the 2006 season at E05PB05.

Variety	Test Harvest Kg/LM**	Productivity M.T./ Ha	% Dry Matter	%Reducing Sugar	Specific Gravity	Tubers Characteristics, and notes on maturity.
Nora	1.111	12.34	18.00	0.21	1.07	Yellow flesh, round oval, long day variety
Camilla	2.422	26.91	20.00	0.02	1.08	Light yellow flesh, round oval, early to medium
Clarina	2.818	31.22	20.80	0.05	1.08	Light yellow flesh, round oval, medium day var.
Topas	2.840	31.56	17.80	0.05	1.07	Yellow flesh, Long oval, short day variety
Agnes	3.828	42.53	18.80	0.13	1.07	Yellow flesh, round oval, Early-Med day variety
Marilen	1.957	21.86	17.00	0.02	1.082	Light yellow flesh, long oval, short day variety
Mustang	3.662	40.69	20.60	0.04	1.08	Red skin, Yellow Flesh, round, medium day var.
Almera	4.057	45.19	19.16*	0.044*	1.075*	Light yellow flesh, long oval tubers, med day
Agria	3.857	42.85	19.16*	0.05*	1.075*	Yellow flesh, oval long, Early-mid main crop.
Sinora	4.477	49.74	20.21*	0.15*	1.077*	Light yellow flesh, oval round, early to medium
Arnova	5.615	62.39	19.58*	0.55*	1.080*	Light yellow flesh, long oval tubers, early-Med
Fontaine	4.525	50.28	20.64*	0.04*	1.082*	Light yellow flesh, oval tubers, the early main crop
Markies	4.955	55.06	20.64*	0.08*	1.082*	Light Yellow Flesh, round oval, medium day var.
L Olympia	3.292	36.58	20.00	.04	1.07	Light yellow flesh color, long oval/oval, medium
Diamant	3.605	40.06	19.00	0.34	1.08	Light yellow flesh color, the oval, early maincrop
Acceptable Level for French fries;			> 19%	< 0.4%	1.076	
Acceptable Level for Chips			> 19%	< 0.2%	1.076	

* Analyzed by ASTRA Lab, ** Mean of 4 linear meters



Mustang



Markies



Fontane



Figure 5. Potato varieties tested in the autumn season of 2006 at E05PB95

Agnes, Topas, Clarina, Camila, and Nora, respectively. The productivity of Agnes was higher than Diamant, and the rest varieties were significantly less than Diamant productivity, see appendix table A. Productivity of Nora variety dropped to 12.09 M.T. per hectare due to damage by Sencor herbicide which caused a delay on the recovery of plants growth consequently the potato plants were damaged by frost occurred on December 5, 2006, when the plants were still actively growing and branching.

- Seven varieties were of top quality regarding % Dry Matter & %Reduce Sugar: Markies, Lady Olympia, Clarina, Mustang, Sinora, Fontane, Camilla. Agria and Almera were with excellent % reducing sugar, but the % Dry Matter was slightly above 19%. The best varieties for French fries were Markies, Fontane and Lady Olympia as they were with high %dry matter, low %reduced sugar, high yield with suitable tuber size and shape; Mustang was a top variety for chips as it was with high %dry matter, low %reduced sugar, round Shape with high productivity.

- Arnova & Almera were with high productivity as they reached 62.39 and 45.09 M.T./Ha, respectively, but they did not reach the acceptable level for processing, so these varieties were suitable as table potato varieties.

B. Observations on the 2008 potato trials:

a) Spring potato 2008 trial at F17P33: Four potato varieties [5], [8] were planted at F17P33 on February 2008 for seed production; these varieties were: Diamant: 13.72 Ha, Markies: 13.72 Ha, Donald: 7.5 Ha, and Vivaldi 7.5 Ha. Test harvest was conducted on May 27, 2008, by randomly harvesting one linear meter from each tower, numbers 4,5,6 and 7. The results of the field observations and laboratory analysis are presented in **Table 4** and **Figure 5**; we observed the following:

- The number of tubers per mean linear meter samples on the different varieties was high.
- The yield of the varieties was acceptable and good under the relatively short spring season; besides, the crop was directed for seed production. Diamant reached 40.33 M.T./Ha, which was higher than other varieties. Vivaldi produced 33.61 M.T./Ha, followed by Donald with 30.39 M.T./Ha then Markies with 28.52 M.T./Ha; the statistical analysis shown no significant yield difference between the varieties.
- Donald showed top quality regarding high %dry matter and low %reduce sugar required for chips and French fries processing followed by Diamant, then Markies, then Vivaldi.
- Statistical Analysis for the productivity of the potato varieties Kg/LM at F17P33 showed no significant difference between the varieties; see appendix table A.

Table 4. Yield and quality measurements on the test harvest of four potato varieties at F17P33 on May 27, 2008.

Potato Variety	A number of tubers/ L.M.	Weight of Tubers/ LM (Kg)				Mean Test Harvest Kg/ L.M*.	Productivity M.T./Ha.	%Dry Matter	%Reducing Sugar	Specific Gravity
		Tower 4	Tower 5	Tower 6	Tower 7					
Markies	36.00	1.94	3.30	2.63	2.40	2.567	28.52	19.0	0.02	1.075
Donald	37.75	2.35	3.5	2.21	2.88	2.735	30.39	21.6	0.01	1.088
Vivaldi	43.75	3.91	3.85	1.78	2.56	3.025	33.61	19.6	0.06	1.078
Diamant	45.50	2.91	3.88	2.41	5.32	3.630	40.33	20.20	0.05	1.081
Acceptable Level for French fries								> 19	< 0.4%	> 1.076
Acceptable Level for chips								> 19	< 0.2%	> 1.076

* Mean of 4 linear meters



Markies Left and Donald right at F17P33



Donald



Vivaldi



Donald French Fries

Figure 5. Potato varieties were tested in the spring of 2008 at F17P33.

b) Spring potato 2008 varieties trial at E10P14: Three potato varieties Diamant, Ditta, Lady Olympia [9], [11], were selected for this trial at E10P14; the area of each variety was 972 M², planted on February 2008 into four rows extending from tower 7 to the end of tower 3 with a length 270 meter and width 3.6 meter. Test harvest was carried out on June 12, 2008. Results are presented in **Table 5, 6,** and **Figure 6,** and we observed the following:

- Diamant emerged one week faster than the other two varieties, and all varieties completed emergence after 47 days from planting. Ditta produced large healthy stems in comparison with Diamant, which showed narrow slender stem shoots. The number of stems/plant was low for Lady Olympia at 1.84; Diamant and Ditta were with a medium number of stems/plant as they reached 2.77, 2.39 respectively. However, the number of stems/one linear meter on the three varieties was similar and ranged from 15.6 – 16.0.

- The number of tubers per one linear meter on the varieties was high, and it reached 46.75 tubers on Ditta, which was the highest, followed by Lady Olympia with 43.00, then Diamant with 34.5 tubers.

- Productivity of Diamant reached 47.50 M.T. /Ha, and this was the highest, followed by Lady Olympia with 43.67 M.T. /Ha, then Ditta reached 42.67 M.T. /Ha. Productivity results were very good under the relatively short spring season. The statistical analysis showed no significant difference in the productivity of the varieties, see appendix table C.

- The percentage of tubers of the size 30 – 45 mm was almost similar on the three varieties and ranged from 26.81 – 28.49. However, the percentage of tubers above 45 mm for Diamant was 43.48%, and this was higher than Lady Olympia and Ditta with 28.49%, 18.72%, respectively. More small size tubers were produced on Ditta, which reached 54.01% and 43.02% on Lady Olympia, while at Diamant, it was 29.74%. These results indicate the period of the spring season was short for Ditta and Lady Olympia.

- Lady Olympia showed top quality regarding high %dry matter and low %reduce sugar required for chips and French fries processing, followed by Ditta and Diamant, and all were suitable for French fries processing.

- Statistical Analysis for the productivity of the potato varieties Kg/LM at E10P14 showed no significant difference between the varieties; see appendix table B.

Table 5. A number of potato tubers per one linear meter and % tubers size on the test harvest of three potato varieties at E10P14 on June 12, 2008.

Potato Variety	Number of stems / LM*	Number of stems/ plant*	Number of Tubers / 1 Linear Meter				Mean Number of tubers/ L.M.*	%Tubers by size in mm		
			Tower 4	Tower 5	Tower 6	Tower 7		< 30 mm	30–45 mm	45–55 mm
Diamant	15.6	2.77	37	34	32	35	34.5	29.74	26.81	43.48
Ditta	16.0	2.39	46	49	56	36	46.75	54.01	27.27	18.72
L. Olympia	15.8	1.84	35	59	41	37	43.00	43.02	28.49	28.49

* Mean of 4 replicates



Varietal trial at E10P14 along with Diamant variety.



Diamant



Ditta



Lady Olympia

Figure 6. Potato varieties tested in spring of 2008 at E10P14

Table 6. Yield and quality measurements* on the test harvest of four potato varieties at E10P14 on June 12, 2008.

Potato Variety	Weight of Tubers/ Linear Meter (Kg)				Test Harvest Kg / LM**	Productivity M.T./ Ha	%Dry Matter	%Reducing Sugar	Specific Weight
	Tower 4	Tower 5	Tower 6	Tower 7					
Diamant	4.57	4.17	4.71	3.65	4.275	47.50	20.00	0.10	1.08
Ditta	3.91	4.54	3.22	3.69	3.840	42.67	21.00	0.19	1.09
Lady Olympia	3.39	5.07	3.80	3.44	3.925	43.67	21.60	0.05	1.09
Acceptable Level for French fries							> 19	< 0.4%	> 1.076
Acceptable Level for chips							> 19	< 0.2%	> 1.076

* Quality Measurement on July 3, 2008

** Mean of 4 replicates

C. a) Spring potato 2009 trial at J02P38: Four potato varieties Mustang, Almera, Fontaine, and Hermes [9], were selected for this trial at J02P38; the seeds were planted on March 3, 2009, into four rows extending from tower 7 to tower 3 with a length 270 meter and width 3.6 meter. Test harvest was carried out on June 20, 2009. The results are presented in **Table 7** and **Figure 7**; we observed the following:

- The productivity of Fontaine variety reached 42.52 M.T./Ha. and this was the highest, followed by Almera with 38.77 M.T./Ha, then Mustang with 30.68 M.T./Ha then Hermes was the lowest with 29.62 M.T. These results were acceptable under the relatively short spring season, besides

the crop was directed mainly for seeds production; the statistical analysis has shown no significant yield difference between the varieties.

- Mustang and Fontaine were with top tubers quality as they were with excellent %dry matter and %reducing sugar. Almera and Hermes were with marginal %dry matter and acceptable %reducing sugar.

- The percentage of potato tubers acceptable for industrial processing of the size 55 – 70 mm reached 46.95, 43.75, 40.25, and 34.85% for Almera, Mustang, Fontaine, and Hermes, respectively.

- Statistical Analysis for the productivity of the potato varieties Kg/LM at J02P38 showed no significant difference between the varieties, see appendix table C.



Almera



Hermes

Figure 7. Potato varieties were tested in the spring of 2009 at J02P38.

Table 7. Productivity and quality measurements on the test harvest of four potato varieties at J02P38 on June 20, 2009.

Potato Variety	% Tuber size in mm				Mean Test Harvest Kg/ LM*	Productivity M.T./Ha.	%Dry Matter	%Reducing Sugar	Specific Weight
	< 45	45-55	55-65	65-70					
Mustang	25.00	31.25	26.56	17.19	2.762	30.68	21.2	0.01	1.086
Almera	14.78	38.26	30.43	16.52	3.489	38.77	21.2	0.01	1.086
Fontaine	15.72	44.03	30.19	10.06	3.827	42.52	18.0	0.19	1.070
Hermes	25.00	40.15	22.73	12.12	2.666	29.62	19.0	0.02	1.075
Acceptable Level for French fries							> 19	< 0.4%	> 1.076
Acceptable Level for chips							> 19	< 0.2%	> 1.076

** Mean of 4 replicates

b) Autumn potato 2009 trial at J39P97: Six potato varieties: King Edward, Mustang, Almera, Fontane, Hermes, and Diamant [9] were selected and planted at J39P97 on August 20, 2009, into four rows extending from tower 7 to tower 3 with a length 270 meter and width 3.6 meter. Test harvest was carried out on December 17, 2009. Results are presented in **Table 8** and **Figure 8**; we observed the following:

- The productivity of Fontaine reached 46.47 M.T./Ha, and this was the highest, followed by Diamant, which reached 37.33 M.T./Ha, then Mustang with 35.19 M.T./Ha then Hermes with 34.33 M.T./Ha then Almera with 30.06

M.T./Ha; King Edward was the lowest with 28.19 M.T. Statistical analysis had shown very high significance between Fontaine and each of the varieties King Edward, Mustang, Almera, Hermes; also significance difference with Diamant, and significant difference between Diamant and each of King Edward, Almera.

- King Edward, Hermes, Mustang, and Fontaine were with top tubers quality as they were with excellent %dry matter and excellent %reducing sugar; Diamant was with acceptable %dry matter, and excellent %reduced sugar. Almera was with low %dry matter and high %reducing sugar.

- The percentage of potato tubers acceptable for industrial 57.29, 68.75, 67, and 82 for Mustang, Diamant, Hermes, Almera, and Fontaine, respectively; King Edward variety was the lowest and reached 34.62%.

- Statistical analysis for the productivity of the different potato varieties as kg/linear meter using Statistics10 had shown a very high significant difference between Fontaine

processing of the size 55 – 70 mm reached 78.89, 76.13, and each of the varieties King Edward, Mustang, Almera, Hermes, and significance difference with Diamant. Also a significant difference between Diamant and each of King Edward, Almera; and significance difference between Mustang and King Edward, see the analysis results of **Table 9**.



Figure 8. Potato varieties tested in the Autumn of 2009 at J39P97.

Table 8 Productivity and quality measurements on the test harvest of six potato varieties at J39P97 on December 17, 2009.

Potato Variety	% Tuber size in mm				Test Harvest Kg/LM*	Productivity M.T./Ha	%Dry Matter	%Reducing Sugar	Specific Weight
	< 45	45-55	55-65	65-70					
King Edward	22.31	43.08	30.00	4.62	2.537	28.19	22.2	0.01	1.086
Mustang	3.33	17.78	28.89	50.00	3.167	35.19	20.6	0.03	1.083
Almera	20.00	11.25	37.50	31.25	2.705	30.06	<18	0.65	<1.070
Fontane	13.91	18.26	31.30	36.52	4.182	46.47	20.8	0.02	1.084
Hermes	10.42	20.83	36.46	32.29	3.090	34.33	21.0	0.13	1.085
Diamant	11.36	12.50	45.45	30.68	3.360	37.33	19.4	0.08	1.077
Acceptable Level for French fries							> 19	< 0.4%	> 1.076
Acceptable Level for chips							> 19	< 0.2%	> 1.076

* Mean of four replicates

Table 9. Test harvest of the different potato varieties in the autumn of 2009 at J39P97

Variety Name	Replicates Kg/L.M.				Total Test Harvest Kg/4 LM	Weight Kg/L.M.	Productivity M.T./Ha.
	Tower 3	Tower 4	Tower 5	Tower 6			
King Edward	2.60	2.64	2.22	2.69	10.15	2.537	28.19
Mustang	3.34	3.16	3.04	3.13	12.67	3.167	35.19
Almera	2.34	2.65	3.52	2.31	10.82	2.705	30.06
Fontane	4.07	4.14	4.50	4.02	16.73	4.182	46.47
Hermes	3.14	2.79	3.81	2.62	12.36	3.090	34.33
Diamant	3.45	4.12	2.90	2.97	13.44	3.360	37.33

Completely Randomized AOV for productivity of the different varieties as Kg per linear meter

Source	DF	SS	M	F	P
Variete	5	6.73544	1.34709	7.91***	0.0004
Error	18	3.06533	0.17030		
Total	23	9.80076			

Grand Mean 3.1738 CV 13.00

Variety	Productivity Kg/LM
King Edward	2.5375
Mustang	3.1675
Almera	2.7050
Fontaine	4.1825
Hermes	3.0900
Diamant	3.3600
Observations per Mean	4

Std Error (Diff of 2 Means) 0.2918

Table T at 95% significance difference for DF 18= 2.101; and at 99% =2.878; at 99.99% = 3.922
 Statistical comparisons for the productivity of the different potato varieties as kg/linear meter Fontane vs King Edward : $4.1825 - 2.5375 / 0.2918 = 5.637^{***}$ (df = 18) = Very high significance.
 Fontane vs Mustang: $4.1825 - 3.1675 / 0.2918 = 3.478^{***}$ (df = 18) = Very high significance.
 Fontane vs Almera: $4.1825 - 2.7050 / 0.2918 = 5.063^{***}$ (df = 18) = Very high significance.
 Fontane vs Hermes : $4.1825 - 3.090 / 0.2918 = 3.744^{**}$ (df = 18) = Very high significance.

Fontane vs Diamant $4.1825 - 3.360 / 0.2918 = 2.819^*$ (df = 18) = Significance difference.
 Diamant vs King Edward: $3.3600 - 2.5375 / 0.2918 = 2.819^*$ (df = 18) = Significance difference.
 Diamant vs Almera: $3.3600 - 2.705 / 0.2918 = 2.245^*$ (df = 18) = Significance difference.
 Diamant vs Hermes: $3.3600 - 3.09 / 0.2918 = 0.925$ (df = 18) = No Significance difference.
 Mustang vs King Edward: $3.1675 - 2.5375 / 0.2918 = 2.159$ (df = 18) = significance difference.
 Diamant vs Mustang : No Significance difference.

D. Observations on the 2011 potato trials:

a) Summer potato 2011 trial: This was arranged by Al Mahlia Co. to visit Maigou area in Al Jouf province to monitor field trial for two American potato varieties: Shepody [13] variety is of Canadian origin used for processing French fries, and Carola is an American table variety of German origin [14]. The seed tubers of each variety, class N2 were planted in this trial on April 23, 2011 along with Hermes main potato crop in a pivot of 46 Ha. Each variety was planted separately into one strip extending from Tower 7 to Tower 1. The total planted area of each variety was around 1440 M². We started test harvest on August 4, 2011, after 102 days planting, choosing five meter line of Carola variety at tower # 6. Manually digging then removing the vigorous foliage to check the tubers. We repeated sampling on four tower locations of each variety, and 10 kg potato tubers samples of each variety were brought to TADCO for quality testing. The results are presented in **Table 10 and Figure 9**, we observed the following:
 - The trial was late planted due to delay in the delivery of potato seeds. Late planting is not ideal for potato production as it may affect productivity and quality of potato tubers dependent on the summer temperature.

- Presence of large amount of sound tubers of good shape, size and color of Carola variety. The tubers are of oblong shape, the skin color and the flesh color was yellow which is attractive for marketing. In the Shepody strip, we observed good potato growth at the levelled areas, and weak growth on the sliding areas which was due to summer stress; the tubers are of long oblong shape, the skin color and the flesh color was creamy white.
- Plant density/linear meter shown Carola was with 5.20 plants which was higher than Shepody with 3.40 plants /LM.
- Estimation of the productivity of Carola variety reached 25.33 M.T. /Ha and this was higher than Shepody with 21.44 M.T. /Ha. Both were low due to unfavorable summer conditions.
- Both varieties were with low tubers quality for French fries processing as the %dry matter reached 18.00 and %reducing sugar was 0.11 for Shepody, and for Carola the %dry matter was high 18.00 and %reducing sugar was 0.03. Frying test of Shepody showed the color grade of French fries was 1-2. Low productivity and low %dry matter is due to growing in summer.
- The percentage of potato tubers suitable for processing reached 53.88% for Shepody and 40.79% for Carola and these results were good.



Summer potato crop of Hermes variety at Al Jouf



Figure 9. Summer potato 2011 of Hermes variety with tested varieties Shepody and Carola at Maigou in Al Jouf province.

Table 10. Productivity and quality measurements on the test harvest of two potato varieties at Maigou area in Al Jouf on August 4, 2011.

Potato Variety	# of plants Per Lm	Tuber Samples		Weight of potato (kg)				Productivity M.T./Ha	%Dry Matter	%Reducing Sugar	Specific Gravity
		# Per /5 LM	weight Kg/5LM	< 50	50-55	55-65	65-70				
Carola	5.20	103	11.4	3.3	1.6	2.8	1.85	25.30	18.00	0.11	1.10
Shepody	3.40	70	9.65	1.8	0.9	2.5	2.7	21.44	18.00	0.03	1.094
Acceptable Level for French fries;									> 19%	< 0.4%	> 1.076
Acceptable Level for Chips									> 19%	< 0.2%	> 1.076

* Mean of four replicates

b) Autumn potato 2011 trial: Two French processing potato varieties seeds samples of Fridor and Oceania [15] were brought from Trescalia dealer in Saudi Arabia. Each sample was 100 kg of F1 class; the seeds were planted at J28P06 on August 14, 2011 for seeds production along with the Markies main potato crop. The area of each variety was 240 M²; each variety was arranged into two beds, each bed of four rows extending into tower 5 and 6 with a length of 33.5 meters at the west side of the pivot. Test harvest was carried out on November 26, 2011 and tubers quality test was conducted on December 6, 2011. The final Harvest of the trial was completed on December 26, 2011. The results are presented in **Table 11 and Figure 10**, we observed the following:

- Oceania variety germinated and emerged one week faster than Fridor, and the two varieties completed emergence after 46 days from planting. The number of potato plants per one linear meter reached 3.65 for Oceania and 3.15 for Fridor.
- The productivity of Oceania variety reached 36.51 M.T. /Ha. and this was higher than Fridor with 31.53 M.T. /Ha

- Fridor was with very good tubers quality for French fries as the %dry matter reached 21.20 and %reducing sugar was 0.18, and Oceania was with very high %dry matter which reached 22.80, the %reducing sugar was 0.20 and the color grade of chips was 1-2.

- The percentage of potato tubers acceptable for seeds planting reached 76.47% for Oceania and 64.12 for Fridor, and both were high, but the percentage of tubers suitable for processing reached 35.88% for Fridor and 23.53% for Oceania, and both were low.

- As per the field observations few plants of both varieties were with symptoms of black leg disease caused by *Pectobacterium caratovorum* [16], [17]. This disease was also observed on few plants of Markies at this pivot. We also observed few plants of both varieties showing symptoms of potato mosaic virus Yn, and we confirmed the virus infection after using diagnostic virus kit [18]. Rouging was carried out to remove the infected plants with the neighboring plants.



(a) Oceania for Chips



(b) Fridor for French Fries



(c) Symptoms of potato mosaic



Figure 10. Potato varieties tested in the autumn of 2011 at J28P06; Tubers of Oceania (a) and Fridor (b); (c) Symptoms of Potato Mosaic Virus Yn; (d1,d2): Symptoms of black leg disease on potato plant, (e) Positive infection with Potato Mosaic Virus Yn.

Table 11. Laboratory and quality measurements on the test harvest and final yield of two potato varieties at J28P06 on December 26, 2011.

Potato Variety	# of plants Per Lm	Test Tubers Samples*		% Tuber size in mm				%Dry Matter	%Reducing Sugar	Specific Gravity	Final Yield Harvest M.T./Ha
		num per/LM	weight Kg/LM	< 45	45-55	55-65	65-70				
Oceania	3.65	34	5.65	20.59	55.88	23.53	0.0	22.80	0.20	1.093	36.51
Fridor	3.15	39	2.841	30.77	33.35	12.78	23.10	21.20	0.18	1.085	31.53
Acceptable Level for French fries; Acceptable Level for Chips								> 19%	< 0.4%	> 1.076	
								> 19%	< 0.2%	> 1.076	

* Mean of four replicates

c) Spring potato 2012 trial: Four potato varieties were selected and planted at the research pivot A04P25 on February 11, 2012. Two French potato varieties Fridor and Oceania [15] class B seeds were chosen to follow up the previous trial carried out on autumn 2011 season at J28P08. Also the other two American varieties Shepody and Carola [13], [14] class A seeds were chosen to follow up previous field observations trial at Al Jouf on August 2011. Potato seeds varieties were planted using four rows planter, rows spacing was 90 cm. As per the available seeds of each variety, the trial consisted two strips for each variety except Fridor it was one strip and one plot, see **Figure 1**. The planted area of each variety with 2 strips = 1188 M² and for Fridor 936 M². Tubers size measurements were carried out on the final harvest on June 11, 2012 and tubers quality tests was carried out on June 18, 2012. The results are presented in **Table 12 and Figure 11**, we observed the following:

- The plants started to emerge after 20 days planting: Oceania emerged faster than Fridor, and it reached 50% emerged plants 40 days after planting, while Fridor variety reached 50% emerged plants after 49 days. Estimation for the number of plants per 10 linear meters was carried out 55 days after planting, Carola reached 4.33 plants/LM and this was slightly higher than Shepody with 4.17 plants/LM. In the other hand, the number of potato plants per one linear meter reached 3.80 plants for Oceania and 3.53 plants for Fridor after 60 days planting.

- The final yield of Oceania variety reached 31.30 M.T./Ha. and this was higher than Fridor with 20.50 M.T./Ha, while the final yield of Shepody reached 20.83 M.T./Ha and this was higher than Carola with 19.28 M.T./Ha. low productivity was due to shortage of irrigation water and increased salinity.

- Both French varieties were with excellent tubers quality for chips and French fries processing as the %dry matter reached 22.20 and %reducing sugar was 0.01 on Oceania, and on Fridor, the %dry matter was 22.0% and %reducing sugar was 0.03%; frying tests was carried out and the color grade of the chips was 1-2. In the other hand both American varieties were with very good tubers quality for French fries processing as the %dry matter reached 20.80 and %reducing sugar was 0.01 on Shepody, while the %dry matter was 19.8 and %reducing sugar was 0.04 on Carola; frying test was carried out, and the color grade of French fries was 1-2.

- The percentage of potato tubers suitable for processing reached 60.98% for Oceania and 41.71% for Fridor, while the percentage of potato tubers suitable for processing reached 19.5% for Carola and 11.05% for Shepody.

Table 12. Field measurements and laboratory analysis results on the spring potato varieties of 2012 season at A04P25.

Potato Variety	# of plants Per Lm	Tuber samples per LM*		% Tuber size in mm				Final Yield M.T./Ha	%Dry Matter	%Reducing Sugar	Specific Gravity
		Tubers number	Tubers weight Kg/Lm *	< 45	45-55	55-65	65-70				
Oceania	3.80	28.2	3.125	15.6	25.53	35.46	23.41	31.30	22.20	0.01	1.091
Fridor	3.53	20.8	2.070	29.8	25.48	29.33	15.38	20.50	22.0	0.03	1.090
Carola	4.33	28.9	1.735	41.9	38.65	15.0	4.50	16.55	19.80	0.04	1.079
Shepody	4.17	42.6	1.875	49.7	39.25	8.75	2.30	19.89	20.80	0.01	1.084
Acceptable Level for French fries; Acceptable Level for Chips									> 19%	< 0.4%	> 1.076
									> 19%	< 0.2%	> 1.076

* Mean of four replicates

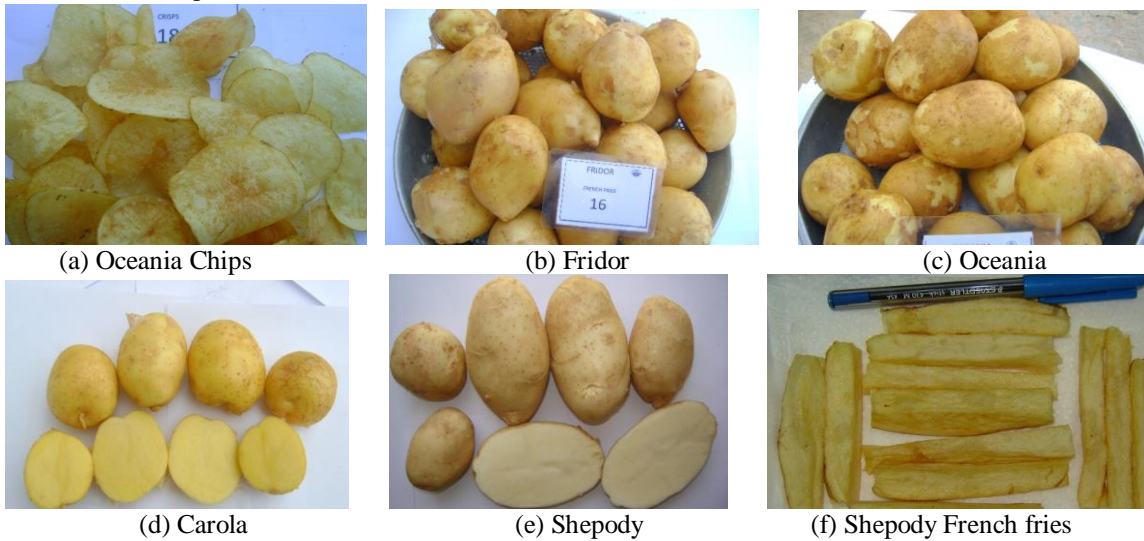


Figure 11. Tubers of potato varieties produced in spring season 2012 at the research pivot A04P25: (a) Chips of Oceania frying color grade # 1-2, (b) Fridor, (c) Oceania, (d) Carola, (e) Shepody, (f) French fries of Shepody frying color grade # 1-2.

Table 12. Field measurements and laboratory analysis results on the spring potato varieties of 2012 season at A04P25.

Potato Variety	Number of plants Per LM	Tuber samples per LM*		% Tuber size in mm				Final Yield M.T./ Ha	%Dry Matter	%Reducin g Sugar	Specific Gravity
		Tubers numbe	Tubers weight	< 45	45-55	55-65	65-70				
Oceania	3.80	28.2	3.125	15.6	25.53	35.46	23.41	31.30	22.20	0.01	1.091
Fridor	3.53	20.8	2.070	29.81	25.48	29.33	15.38	20.50	22.0	0.03	1.090
Carola	4.33	28.9	1.735	41.85	38.65	15.0	4.50	16.55	19.80	0.04	1.079
Shepody	4.17	42.6	1.875	49.70	39.25	8.75	2.30	19.89	20.80	0.01	1.084
Acceptable Level for French fries; Acceptable Level for Chips									> 19%	< 0.4%	>
									> 19%	< 0.2%	1.076 > 1.076

Statistical analysis for the productivity of the different potato varieties (kg/linear meter) using Statistics10 is presented in the following **Table 13**:

Table 13. Productivity of the different potato varieties in the autumn of 2009 at J39P97

Name of Variety	Mean Weight (Kg)/LM*		Total Weight (Kg)	Mean Weight (Kg) / L.M.
	I	II		
Carola	1.62	1.85	3.47	1.735
Shepody	1.82	1.93	3.75	1.875
Fridor	1.93	2.21	4.14	2.070
Oceania	3.53	2.72	6.25	3.125

* * Mean of 10 Linear Meter

Completely Randomized AOV for productivity of the different potato varieties as kg/linear meter

Source	DF	SS	MS	F	P
Varieties	3	2.38874	0.79625	7.97*	0.0366
Error	4	0.39975	0.09994		
Total	7	2.78849			

Grand Mean 2.2013 CV 14.36

Grand Mean 2.2013 CV 14.36

Variety	Kg/LM
Carola	1.7350
Shepody	1.8750
Fridor	2.0700
Oceania	3.1250

Observations per Mean	2
Standard Error of a Mean	0.2235
Std Error (Diff of 2 Means)	0.3161

Table t at 95% significance difference for DF 4 = 2.776. Statistical analysis had shown: High significance difference between Oceania and each of the varieties Carola, Shepody and Fridor: T value for Oceania vs Carola = $3.125 - 1.735 / 0.3161 = 4.3397^*$ (df = 4) significant difference:

T value for Oceania vs Shepody : $3.125 - 1.875 / 0.3161 = 3.954$ (df = 4) significant difference
T value for Oceania vs Fridor: $3.125 - 2.070 / 0.3161 = 3.337$ (df = 4) significant difference
No significance between the other varieties.

1V. SUMMARY & CONCLUSIONS

1- Eight potato varietal field trials were conducted during the period 2006 – 2012 to find the suitable and profitable potato varieties suitable for chips and French fries to satisfy the company profitability and the requirements of the local processing factories of consistent supply of good quality potato. Five field trials were conducted in the spring seasons: one in 2006, two in 2008, one in 2009 and one in 2012. Two field trials were conducted in the autumn seasons: one in 2006 and one in 2009; and another observation trial in summer 2011. Productivity of the varieties varied over the years dependent on climatic conditions and pivot location which is affected by soil type, texture and fertility, available

irrigation, so main potato crop variety like Diamant or Lady Olympia or Hermes was considered as control.

2- During our research progress on potato varieties suitable for processing, we considered the important factors affecting tubers qualities for chips and French fries processing [19] including:

- Adaptation of the variety to the local climatic conditions where the variety is of early to medium day length to grow and complete its life cycle within the favorable climatic conditions with medium dormancy duration.
- Productivity under local conditions is medium to high with consistent tubers quality regarding shape is round oval to oval, flesh is light yellow or creamy white, with smooth tuber surface.

- Some degree of resistance to local diseases such as blights, black leg, fusarium dry rot, common scab, potato virus Yn etc.

- The variety is manageable under mechanical operations and in particular harvest, transport and storage. So the tubers were not sensitive for mechanical bruising like shattering, skinning, internal black spots, hollow heart etc. [20]. consequently post-harvest losses was minimized

- Satisfy the requirements of the end user regarding the tubers were with high %dry matter, low %reduced sugar; and pass the frying test, so the color of the chips or French fries is of grade 1 – 2, low oil absorption and the taste of the finished product is good and acceptable to the end user. High recovery rate of the processed product from the raw material like on Diamant, so the cost of production per unit was decreased.

3- Results on the spring potato 2006 trial showed two potato varieties of high productivity and high quality, and they were suitable for processing French fries and chips: Markies with productivity 46.11 M.T./Ha, %dry matter 21.40%, %reduced sugar 0.01; Mustang variety was a red skin with productivity 41.67 M.T./Ha, %dry matter 21.0, %reduced sugar 0.01. Results also showed two table varieties of high productivity: Arnova with 63.89 M.T./Ha and Almera with 40.56 M.T./Ha. Five potato varieties from Europlant were with good qualities for processing, but they were with low productivity which ranged 19.44 – 26.67 M.T./Ha. We also observed two varieties suitable for processing with medium productivity: Fontane with 36.87 M.T./Ha and Agria with 34.44 M.T./Ha. The autumn trial results confirmed high productivity and high quality of Markies variety with 55.06 M.T./Ha, %dry matter 20.54, %reduced sugar 0.08 followed by Fontane [21] with 50.28 M.T./Ha, %dry matter 20.64, %reduced sugar 0.04 then Sinora with 49.74 M.T./Ha, %dry matter 20.21, %reduced sugar 0.04. Results also showed three varieties Agria, Mustang and Diamant were with productivity above 40.0 M.T./Ha and the tubers were with high quality. Results also showed the productivity of the table variety Arnova was high with 62.39 M.T./Ha followed by the table variety Almera with 45.19 M.T./Ha. Productivity of the five potato varieties from Europlant were improved in this season in comparison with spring season, and the productivity ranged 26.91 – 42.53 M.T./Ha: two varieties Clarina and Camilla were of high quality for potato processing. Nora productivity was very low 12.09 M.T./ha due to damage by Sencor herbicide which caused delay on the recovery of plants growth consequently the potato plants were damaged by frost occurred on December 5, 2006.

4- The field measurements and laboratory analysis results on the spring potato of 2008 field trial showed the productivity of four potato varieties ranged 28.52 – 40.33 M.T./Ha which is normal for the relatively short season in spring period. Diamant variety reached 40.33 M.T./Ha, and this was higher than the other varieties followed by the baby variety Vivaldi with 33.61 M.T./Ha. The new variety Donald variety

produced 30.39 M.T./Ha with high %dry matter 21.60 and low % reduced sugar 0.05, and it proved to be a good variety for processing chips and French fries. Markies variety dropped to 28.59 M.T./Ha due to low quality of old seeds; %dry matter was marginal 19.0 with low %reduced sugar. Another potato field trial was conducted in the spring of 2008 on one potato variety Ditta and one old variety Lady Olympia along the main crop Diamant variety. Results showed the productivity of Diamant reached 47.50 M.T./Ha, and this was the highest followed by Lady Olympia with 43.67 M.T./Ha then Ditta was the lowest with 42.67 M.T./Ha. The three potato varieties were with high quality for processing, and Lady Olympia was with the highest %dry matter 21.6 and the lowest %reduced sugar 0.05.

5- Results on the spring potato 2009 trial showed the productivity of Fontane variety reached 42.52 M.T./Ha, and this was the highest followed by Almera with 38.77 M.T./Ha then Mustang with 30.68 M.T./Ha then Hermes was the lowest with 29.62 M.T. These results were acceptable under the relatively short spring season. Mustang and Fontane were with top tubers quality as they were with high %dry matter and low %reducing sugar. Hermes was with marginal %dry matter and low %reducing sugar; Almera was with low %dry matter as this is table variety [9]. Results on the autumn potato 2009 trial showed the productivity of Fontane variety reached 46.47 M.T./Ha and this was significantly higher than each of other varieties followed by Diamant with 37.33 M.T./Ha then Mustang with 35.19 M.T./Ha then Hermes with 34.33 M.T./Ha then Almera and King Edward with 30.06, 28.19 M.T. respectively. Productivity in 2009 results was less than productivity in autumn 2006 apparently due to less fertility at J39P97 than at F18P35. King Edward, Mustang and Fontaine were with top tubers quality as they were with high %dry matter and low %reducing sugar. Hermes was with marginal %dry matter and low %reducing sugar; Almera was with low %dry matter as this was table variety [14].

6- Observations on the summer 2011 field trial at Al Jouf on two potato varieties imported from USA and planted in the middle of the main potato crop of Hermes variety showed low productivity of both varieties of Shepody and Carola with 21.40, 25.30 M.T./Ha respectively. This was due to late planting the trial on April 23, 2011 as there was delay in the delivery of the seeds. Both varieties were with low tubers quality for processing as Shepody was with 18.0% dry matter and 0.04% reduced sugar, and Carola was with 18.0% dry matter and 0.06% reduced sugar. Management of soil temperature in this area through night irrigations helped to save the varieties from high day temperature and produce reasonable yield and in particular the main crop of Hermes variety required for the French fries factories during summer. Based on field observations: Shepody tubers were oval long shape with white skin and white flesh, and they were suitable for French fries; and Carola tubers were oval shape with yellow skin and yellow flesh suitable as table potato.

7- Results on the autumn potato 2011 trial on two French potato varieties planted in the middle of the main crop variety Markies showed the productivity of Oceania was 36.51 M.T./Ha and this was higher than Fridor with 31.53 M.T./Ha. Fridor was with very good tubers quality for French fries as the %dry matter reached 21.20 and %reducing sugar was 0.18, while Oceania was with very high %dry matter which reached 22.80, and the %reducing sugar was 0.20.

8- Results on the spring potato 2012 trial of four potato varieties showed the final yield of Oceania was 31.30 M.T./Ha and this was higher than other varieties. The final yield of Fridor, Shepody and Carola dropped to 20.50, 19.89, 16.55 M.T./Ha respectively; low productivity was due to shortage of irrigation water at A04P25. M.T./Ha. Three varieties were of top quality for processing: Oceania, Fridor and Shepody: frying tests showed both Fridor and Shepody were suitable for French fries with color grade 1-2, while Oceania was suitable for chips with color grade 1-2. Carola tubers were with yellow skin, yellow flesh, marginal %dry matter, and the taste was excellent, so this variety was suitable as table potato.

9- Summing up the results: marketable and profitable new potato varieties were characterized by high to medium productivity, high quality in terms of high dry matter, low reduced sugar [6], [7], the color of the chips or the French fries is grade 1-2 and accepted by the end user. The results showed the following promising varieties:

Markies: Medium day, large tubers size, oval long, light yellow flesh, high productivity, good storageability, very

good quality for chipping.

Mustang: Early main crop, medium tubers size, red skin, oval, cream flesh, medium to high productivity, excellent quality for chipping.

Fontane: Early main crop, large tubers size, oval, light yellow flesh, high productivity, very good quality for chipping.

Donald: Medium early variety, medium tubers size, oval, medium yellow flesh, medium to high productivity, very good quality for chipping (high dry matter), medium dormancy, sensitive to bruising during mechanical harvest, sensitive to black leg disease.

Lady Olympia: Medium main crop, normal tubers size, oval long, light yellow flesh, high productivity, good storageability, good quality for chipping. Resistant to PVYn. production stopped at TADCO.

Oceania: Medium early, medium tubers size, oval, yellow skin and flesh, medium productivity, good quality for chipping.

Fridor: Medium day, medium tubers size, oval, yellow skin and flesh, medium to low productivity, good quality for chipping.

Arnova table potato variety [9] was observed with high productivity of 63.89 M.T./Ha in the 2006 spring season; it was an early-medium day variety, big tubers size, oval long, light yellow flesh.

Over the years, successful potato varieties were adapted by the company for crop production like Markies, Mustang, Donald, and Hermes or abandoned due to technical reasons like Agria and Lady Olympia.

APPENDIX TABLES

Appendix Table A. Test Harvest of potato varietal trial in the spring of 2008 at F17P33.

Variety	Weight of tubers/LM (Kg)				Total Weight/4 LM	Mean Weight of Tubers/L.M.	M.T./Ha.
	Tower 4	Tower 5	Tower 6	Tower 7			
Diamant	2.91	3.88	2.41	5.32	14.52	3.630	40.330
Markies	1.94	3.30	2.63	2.40	10.27	2.567	28.560
Donald	2.35	3.50	2.21	2.88	10.94	2.735	30.440
Vivaldi	3.91	3.85	1.78	2.56	12.10	3.025	33.667

Statistical Analysis for the productivity of the potato varieties at F17P33 Completely Randomized AOV for the productivity Kg/LM

Source	DF	SS	MS	F	P
Varieties	3	2.6174	0.87247	1.03 N.S.	0.4133
Error	12	10.1479	0.84566		
Total	15	12.7653			

Grand Mean 2.9894 CV 30.76

Appendix Table B. Test Harvest of potato varietal trial in the spring of 2008 at E10P14.

Name of Variety	Replicates Kg/L.M.				Total Weight Kg/4 L.M.	Mean Weight Kg/L.M	Yield M.T./Ha.
	Tower 4	Tower 5	Tower 6	Tower 7			
Diamant	4.57	4.17	4.71	3.65	17.10	4.275	47.50
Ditta	3.91	4.54	3.22	3.69	15.36	3.840	42.67
Lady Olympia	3.39	5.07	3.80	3.44	15.70	3.925	43.67

Statistical Analysis for the productivity of potato varieties at E10P14
Completely Randomized AOV for the productivity kg/LM

Source	DF	SS	MS	F	P
Varieties	2	0.42527	0.21263	0.56 N.S.	0.5908
Error	9	3.42780	0.38087		
Total	11	3.85307			

Grand Mean 4.0133 CV 15.38

Appendix Table C. Test harvest of potato varietal trial in the spring of 2009 at J02P38

Name of Variety	Replicates Kg/L.M.				Total Weight Kg/4 L.M.	Mean Weight Kg/L.M	Yield M.T./Ha.
	Tower 4	Tower 5	Tower 6	Tower 7			
Mustang	3.924	2.856	2.110	2.156	11.046	2.762	30.67
Almera	3.228	2.728	3.780	4.218	13.954	3.489	38.78
Fontane	4.240	3.058	3.834	4.174	15.306	3.827	42.56
Hermes	3.172	2.398	2.560	2.534	10.664	2.666	29.67

Completely Randomized AOV for the productivity kg/LM

Source	DF	SS	MS	F	P
Varieties	3	3.80938	1.26979	3.27 N.S.	0.0588
Error	12	4.65369	0.38781		
Total	15	8.46307			

Grand Mean 3.1856 CV 19.55

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